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None

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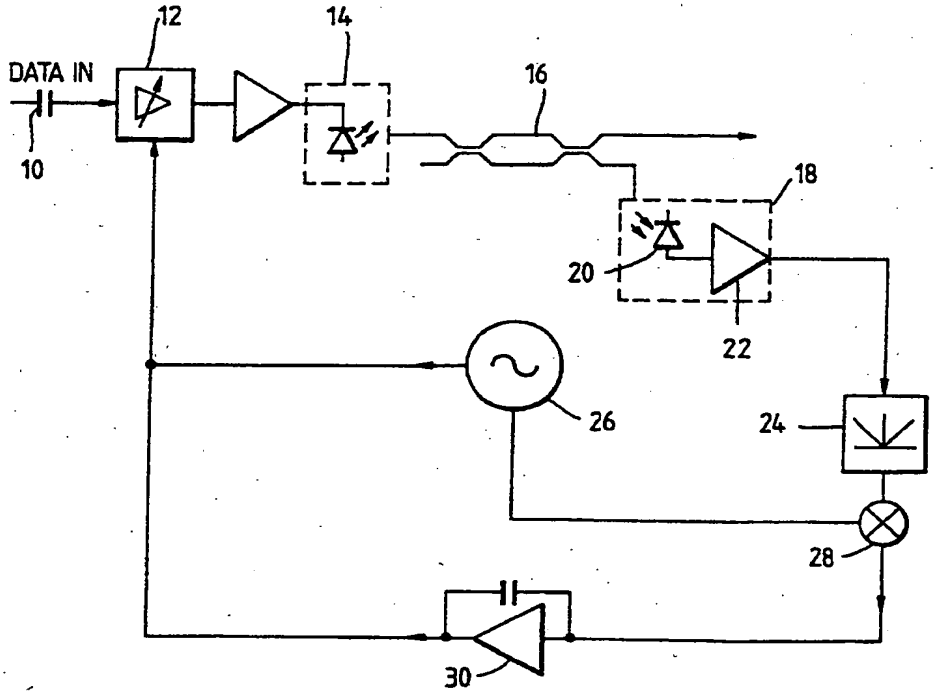
ONLINE DATABASES : WPI

(54) Optical transmitter

(57) A method of controlling the depth of modulation of an optical source 14 in a frequency shift keyed intensity modulation optical transmitter, the method including the steps of impressing on a digitally modulated drive signal for the source an amplitude modulation at a frequency less than that of the digital signal, detecting at 24 the envelope of the transmitted signal, multiplying the detected envelope signal with the impressed frequency and deriving therefrom a control signal to control the depth of modulation of the source.



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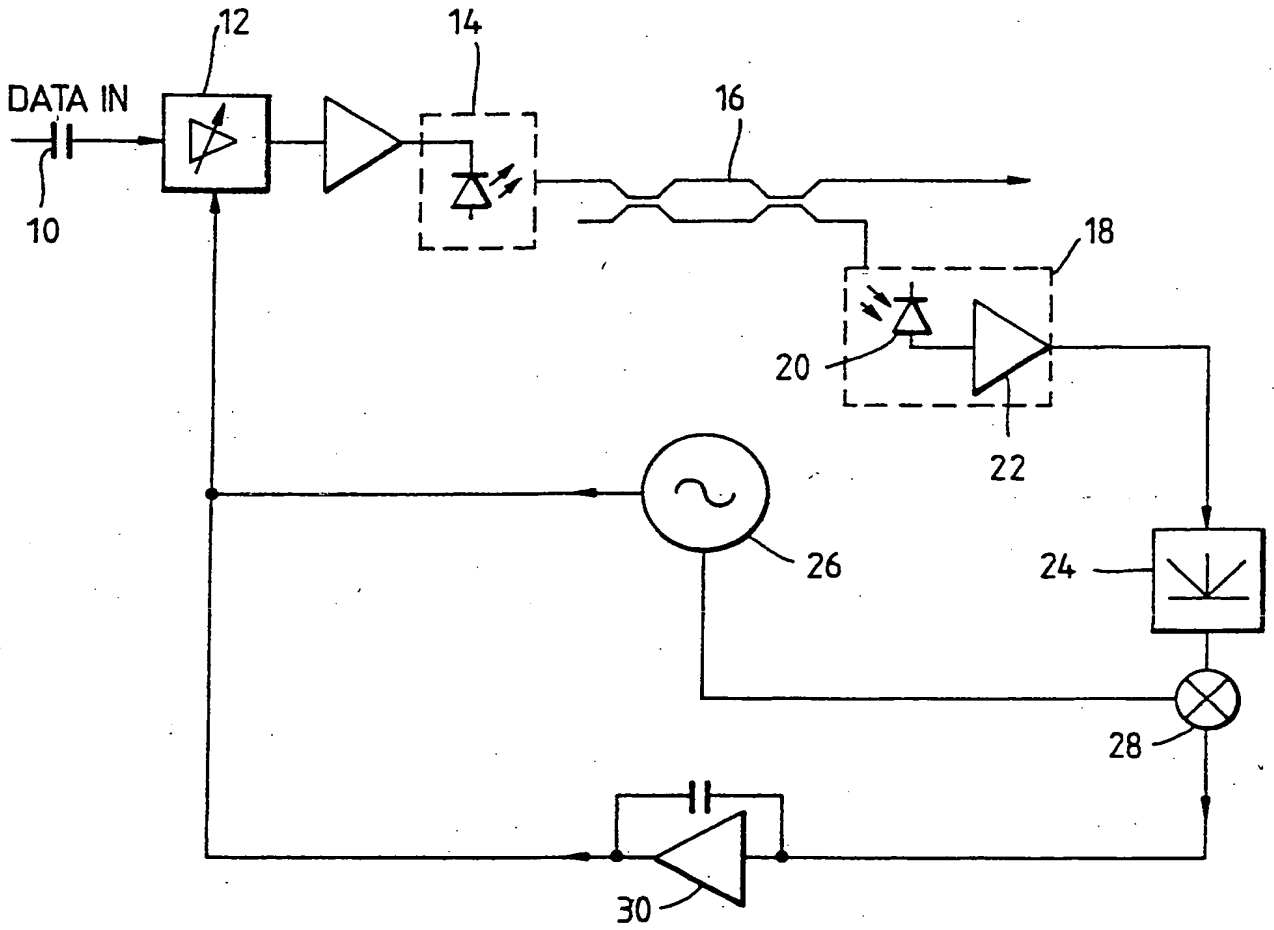
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.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Modulation depth control for FSK/IM optical transmitter

This invention relates to modulation depth control for a frequency shift keyed (FSK) intensity modulated (IM) optical transmitter, such as may be used in a long haul telecommunications transmission system.

The principle of FSK/IM transmitters is that small modulation depth signals imposed on the bias current of an injection laser result in optical frequency changes of the laser output, with a small but negligible amplitude variation. Putting the light through an optical frequency discriminator converts the frequency modulated input into intensity modulation at the output. By choosing an appropriate optical frequency discriminator, relatively small modulation depth drive signals to the laser bias can be used to provide substantially 100 % intensity modulation at the discriminator output. Such an arrangement is disclosed in British patent GB 2 107 147B. Compared to direct intensity modulation of the laser, where large drive current swings are required, this technique yields a much lower chirp transmitter source, which is important for high speed or medium and long haul systems. Typically use is made of a DFB laser followed by a Mach-Zehnder (M-Z) interferometer optical discriminator.

In a practical system, if the M-Z characteristic or the

centre frequency of the laser drifts the extinction ratio of the IM output is deteriorated, so a compensatory centre frequency control loop is needed. A control scheme which does this has been described in British Patent application 91 06045.9.

The present invention seeks to provide a method and means for controlling the modulation depth in a FSK/IM optical transmitter to compensate for any changes in the laser output frequency vs. injection current characteristic which may be caused by temperature changes and/or by laser ageing. It is important that the laser bias deviation induced by the modulation signal has the correct amplitude, so that the optical frequencies representing the binary '1' and '0' logic levels correspond to the maximum and minimum transmission characteristics of the M-Z interferometer. Modulation depth can be preset by adjustment of a dc control voltage presented to a variable gain amplifier in the laser drive circuitry.

According to the present invention there is provided an optical transmitter having an optical source adapted to produce a frequency shift keyed (FSK) optical output in response to the application thereto of a drive signal modulated by a digital signal, which FSK output is fed through an optical frequency discriminator to convert the modulation of the optical output from FSK to intensity modulation (IM), the transmitter including a feedback control loop adapted to control the depth of modulation of the optical source, wherein the feedback control loop includes means to impress on the drive signal applied to the optical source an amplitude modulation at a frequency less than that of the digital signal, the transmitter further including means for extracting from the transmitter output the envelope of the output signal, means for multiplying the detected envelope with the amplitude modulation signal and means for deriving from the output of the multiplying means a control signal to control the depth of modulation of the optical source.

An embodiment of the invention will now be described with reference to the accompanying drawing which is a block schematic of a modulation depth control arrangement for an optical transmitter.

In the arrangement shown incoming binary encoded digital data is applied via a decoupling capacitor 10 to a variable gain amplifier 12 the output of which forms the modulated bias current for a DFB injection laser 14. The FSK output of the laser 14 is fed into a Mach-Zehnder interferometer 16. One output of the M-Z interferometer is the IM optical signal for transmission, the other output feeds a monitor circuit 18 which comprises a photodiode 20 and amplifier 22.

To provide a modulation depth control to compensate for any changes in laser output frequency vs. injection current response, which might be caused by temperature changes or laser ageing, a feedback control loop is employed. This loop must ensure that the frequency deviation induced by the digital data modulation signal has the correct amplitude, so that the optical frequencies representing binary "one" and "zero" logic levels correspond to the maximum and minimum transmission of the M-Z interferometer. At present modulation depth has been preset by adjusting a d.c. control voltage presented to the variable gain amplifier 12 in the laser drive chain. The feedback includes an oscillator 26 running at a low frequency, say 6Khz, compared to the data frequency, which may be in the giga Herz range. The output of the oscillator is impressed on the d.c. control voltage of variable gain amplifiers 12 to cause a low level amplitude modulation of the laser output. The feedback loop also includes an envelope detection circuit 24 to which the output of the monitor circuit 18 is applied. The output of the envelope detector will have the nominal 6Khz tone imposed on it and this signal will be in phase with the oscillator output when the modulation depth is too small and out of phase when it is too large. The feedback loop therefore includes a multiplier 28, in

which the output of the envelope detector is multiplied by the oscillator output, and an integrator circuit 30 to which the output of the multiplier is applied. The output of the integrator circuit 30 is applied to vary the d.c. control voltage to the variable gain amplifier 12.

It should be noted that the output of the M-Z interferometer feeding the monitor circuit does not need to have the full data bandwidth; a portion of the low frequency end of the data spectrum is sufficient. Although the instantaneous amplitude of the control signal will vary as the data content inside the envelope detector bandwidth fluctuates, this effect can be averaged out by making the time constant of the integrator circuit sufficiently large.

CLAIMS:

1. An optical transmitter having an optical source adapted to produce a frequency shift keyed (FSK) optical output in response to the application thereto of a drive signal modulated by a digital signal, which FSK output is fed through an optical frequency discriminator to convert the modulation of the optical output from FSK to intensity modulation (IM), the transmitter including a feedback control loop adapted to control the depth of modulation of the optical source, wherein the feedback control loop includes means to impress on the drive signal applied to the optical source an amplitude modulation at a frequency less than that of the digital signal, the transmitter further including means for extracting from the transmitter output the envelope of the output signal, means for multiplying the detected envelope with the amplitude modulation signal and means for deriving from the output of the multiplying means a control signal to control the depth of modulation of the optical source.

2. An optical transmitter according to claim 1, wherein the optical source is a DFB injection laser driven by the output of a variable gain amplifier the gain of which is modulated by the digital signal.

3. An optical transmitter according to claim 1 or 2 wherein the drive signal is generated by a voltage controlled variable gain amplifier to which the digital signal is applied, the control signal being in the form of a dc signal imposed on a preset dc control of the variable gain amplifier.

4. An optical transmitter according to claim 1, 2 or 3, wherein the optical frequency discriminator is a Mach-Zehnder interferometer.

5. An optical transmitter including a feedback control loop adapted to control the depth of modulation of the transmitter substantially as described with reference to the accompanying drawings.

6. A method of controlling the depth of modulation of an optical source in a frequency shift keyed intensity modulation optical transmitter, the method including the steps of impressing on a digitally modulated drive signal for the source an amplitude modulation at a frequency less than that of the digital signal, detecting the envelope of the transmitted signal, multiplying the detected envelope signal with the impressed frequency and deriving therefrom a control signal to control the depth of modulation of the source.

7. A method according to claim 6 wherein the optical source is an injection laser and the control signal is applied to control the amplitude of the modulation of the drive current applied to the laser.

8. A method of controlling the depth of modulation of an optical source in a frequency shift keyed intensity modulation optical transmitter substantially as described with reference to the accompanying drawings.

'atents Act 1977
Examiner's report to the Comptroller under Section 17 (Th Search Report)

Application number
GB 9215554.8

Relevant Technical fields

(i) UK Cl (Edition K) H4B: BK14C2D; BK14D2; BK14D2B; BK14D2C; BK14D2D

(ii) Int Cl (Edition 5) H04B

Search Examiner
ALAN STRAYTON

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search
16 SEPTEMBER 1992

Documents considered relevant following a search in respect of claims ALL

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

Category	Identity of document and relevant passages	Relev to claim(s)

Cat gories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the sam category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databas s: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

INVESTOR IN PEOPLE

Application No: GB 0317632.8
Claims searched: 4 and 10

Examiner: Rosalind Lyon
Date of search: 17 December 2003

Patents Act 1977 : Further Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
A		EP 0488226 A1	FUJITSU See especially page 3 lines 5-23
A		GB 2269067 A	NORTHERN TELECOM LTD See especially page 2 para 3

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{V} :

G2F, H4B

Worldwide search of patent documents classified in the following areas of the IPC^{7} :

G02F, H04B

The following online and other databases have been used in the preparation of this search report :

WPI, EPODOC, JAPIO